DOCUMENT RESUME

ED 309 755 IR 013 913

AUTHOR	Plomp, Tjeerd
TITLE	Integration of Computers in Education: A Curriculum Perspective.
PUB DATE	Jul 88
NOTE	28p.; Paper presented at the European Conference on Information Technology in Education (EURIT) 88 Conference (Laussanne, Switzerland, July 25-29, 1988).
PUB TYPE	Information Analyses (070) -- Viewpoints (120) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Adoption (Ideas); *Computer Assisted Instruction; Courseware; *Curriculum Development; Instructional Innovation; *Learning Processes; *Media Selection; Models; Teacher Attitudes; *User Needs (Information)

ABSTRACT

This discussion of a major problem area in education--the curricular and implementation aspects of the application of the computer or new information technologies--focuses first on the use and integration of computers in existing courses or subjects in the curriculum, and defines some key terms. The next section considers issues in the implementation of educational innovations: (1) how to involve the large group of non-using teachers in the integration of computers in the school's curricula; (2) how to integrate the computer into the formal curriculum, including evaluating the quality of educational software; (3) how to integrate computers into the operational curriculum, including teacher-learning activities such as selection of software and unanticipated problems with teachers' existing instructional roles; and (4) relation to curriculum implementation from the teachers' perspective--e.g., instrumentality, congruence, and cost--and the innovation perspective--e.g., clarity, complexity, consensus and conflict, and quality and practicality of innovation products. The question of whether the computer is an adequate instructional medium is then considered by examining models of both the learning process and the instructional process. It is noted that within each instructional function the teacher can choose instructional methods and media from an array of combinations. A final section explores the issue of how to design educational software in such a way that a teacher will be able to use it in his/her operational curriculum in the way intended by the developer. (47 references) (CGD)

Department of Education
Division of Curriculum Technology and Educational Administration

Ref. : TO.21.88.667
Date: September 29, 1988

INTEGRATION OF COMPUTERS IN EDUCATION:

A CURRICULUM PERSPECTIVE

Tjeerd Plomp
Department of Education
University of Twente
Enschede, The Netherlands

Paper presented at the Eurit 88 conference, Laussanne (Switz.), 25-29 July 1988.

INTEGRATION OF EDUCATIONAL COMPUTING ON THE CURRICULUM

1. INTRODUCTION

In the opening address of the first European Conference on Information Technology in Education, Eurit '86, we stated the question whether we can expect that, when the problems of teacher training, hardware provision and educational software development are being solved to a great extent, computers will be used intensively as a tool by teachers (next to other, more traditional tools) and also that our computer aided educational systems will be better in many respects (e.g. better outcomes, more flexible, more individualized) than our present systems. We then answered this question negatively (Plomp & van den Akker, 1987; xxxii).

In many discussions about problems with the introduction of computers in education as well as in many research projects on computers in education, one has chosen as an implicit starting point the potential of the new technology for education. This can be justified, because all facets of something new have to be studied carefully before one can say something meaningful about possible uses and applications. In another chapter Collis (1988a) gives a brief summary of what we know at present.

However, the reverse is not true: when we have demonstrated the educational usefulness and potential of the computer, then we may not expect that eduation will be enriched and improved automatically by the introduction of computers in the schools or that teachers will implement new technologies without problems in their daily teaching routines.

Despite many initiatives and the large numbers of computers in schools, one can hardly speak of successful integration and implementation of computers in the teaching-learning processes in schools. This conclusion can be drawn from many surveys and case studies in e.g. the USA (Becker, 1986; Martinez & Mead, 1988), Canada (Collis, Kass, Kieren & Woods (1988), the Netherlands (Inspectie, 1987; Plomp & Van den Akker, 1988) and England (Cox, 1987). The conclusion of the Dutch Inspectorate is illustrative: "Integration of the computer in the teaching/learning process has hardly been found. Often there is no other reason for working with the computer than that it is the student's turn" (Inspectie, 1987, p.7). The surmise is that the disappointing experiences are a consequence of insufficiently taking into account of factors which are crucial when introducing educational change (e.g. Knupfer, 1986; Plomp, Steememan & Pelgrum, 1988), has resulted in an increasing attention for curricular and implementation aspects of the introduction of computers in education.

The introduction of computers in education is a complex innovation which encompasses more than just bringing the hardware, the software packages and some trained teachers in our

schools It may ask for new teaching strategies, for other types of classroom (and school) organization, for other roles and tasks of the teachers, for other relationships between teachers and students, and even for new courses or new emphases in the content and methods of existing courses. These examples illustrate that next to the three problem areas mentioned before, the curricular and implementation aspects of the application of the computer, or more generally of new infomation technologies, in education is a fourth major problem area.

In this chapter we will discuss this fourth problem domain with an emphasis on the curricular aspects. We will not deal with new courses on computer literacy or computer science, but focus on the use, or preferably the integration, of computers in existing courses or subjects in the curriculum. In Section 2 we will first describe some of the key concepts being discussed in this paper. Then in Section 3 some results of pertinent research will be summarized.

Having defined what we understand by the integration of computers in the curriculum and what we know about it, we will further restrict our topic in Section 4 to two questions for the curriculum and courseware developer: what strategy can be followed to determine whether and how to use the computer in a curriculum (Section 5) and what factors should be taken into account when we develop courseware for teachers who are inexperienced users of computers (Section 6). This chapter will be concluded with some remarks (section 7).

2. INTEGRATION OF COMPUTER USE IN THE CURRICULUM

Computer use

It is difficult to give a clear and unambiguous description of integration of computer use in the curriculum, because its three elements -- integration , computer use and curriculum -- are each multi- facetted concepts.

The use of computers will be described very briefly. We are referring here to typologies such as Taylor's (1980) functions of the computer as a tool, tutor, or tutee; or to the well known lists of varieties of programs (tutorial instruction, drills, simulations, etc.; see for example Alessi & Troliip, 1985). We will assume that the reader is familiar with such categories. When we are talking of computer use we will refer generally to anyone of these uses or applications.

Curriculum

A curriculum in an educational context means almost literally "a plan for learning" (Taba, 1962). We will restrict ourselves mainly to curricula on the micro level, which is the level of the concrete teaching-learning situation. The products and documents on this level are referred to as curricular materials, or courseware, when software is included. (The micro level can be distinguished from the macro and meso levels. On the macro level we may have, for

example, national syllabuses for school types or subject matter domains, while on meso level a school may have its own similar types of documents.)

For our purpose we need two other types of specifications. First, we can distinguish **curriculum components or dimensions** (Gerlach & Ely, 1980; Leithwood, 1981), such as objectives, content, instructional strategies (including methods and media), grouping patterns, materials, student evaluation, time, and space. When we are talking about computers in the curriculum, we are in principle referring to all eight components of the curriculum. Integration of computers in school curricula may affect any of these components.

Another distinction which is appropriate for analysis purposes is the curriculum typology of Goodlad, Klein, and Tye (1979). They use five manifestations of curricula:

- **ideal curriculum**: the abstract curriculum defined by the starting points and believes of the designers;
- **formal curriculum**: the codification of the curriculum in documents and other materials;
- **perceived curriculum**: the curriculum as perceived or interpreted by the the teacher;
- **operational curriculum**: the plan of learning in operation; the actual execution of the curriculum, during the teaching-learning process;
- **experiential curriculum**: the curriculum as experienced by the students, in relation to different types of learner outcomes.

When we are referring to the use of computers in the curriculum we are in fact referring to one or more of Goodlad, Klein and Tye's manifestations of the curriculum, and at each manifestation to one or more of Gerlach and Ely's components of the curriculum (see Fig. 1).

-- Insert Figure 1 about here --

Integration of computers in education

We agree with Mudd and Wilson (1987) that the integration of computers in a curriculum has a quantitative as well as a qualitative dimension (Steerneman, 1988). The **quantitative** aspect refers to descriptive variables indicating the frequency and intensity of computer use. For example, at the school level we may think of the number of subjects, grades, classes per grade, teachers per subject, and numbers of students (all or a special group) who use school computers. Within subjects, integration refers to variables such as the frequency of use per student per time period, the time spent on the computer each time it is used, and the number of software packages being used. **Qualitative** aspects are those referring to types of objectives; to teachers'activities or the lesson phases in which the computer can be used (such as presentation of new subject matter, practising, testing, feedback); to students'

activities, and to the 'level' or complexity of computer applications, which may vary from a relatively low level of drill and practice or word processing to more sophisticated applications such as simulations or computer coaches. The integration of the computer in the curriculum in both is quantitative and qualitative aspects can be discussed for each curriculum manifestation (Fig.1).

In this chapter we will concentrate on two particular aspects of computer manifestions, the formal and the operational curriculum, because we will discuss the issue of computers in the curriculum from the two-fold perspective of the curriculum developer and of the teacher. The curriculum developer as well as the educational software developer are working at the level of the formal curriculum by developing curricular materials, while the teacher when working with curricular materials in his or her classroom is realizing the operational curriculum. A discrepancy between the formal and operational curriculum may be a consequence of the teacher's interpretation of the curricular materials being used (for example, the teacher's interpretation of parts of the materials may not match the intentions of the curriculum developer; this may lead to a decision to neglect parts of the materials and/or to use self-developed materials). As much of the educational software which is being used in schools is (or will be) externally developed it is important that courseware developers are working to consciously anticipate a range of possible perceptions of the users of their products (perceived curriculum). It has been hypothesized that a necessary condition for an optimal operational curriculum (that is for optimal use of educational software in instructional practice) is that the teacher's interpretation of the formal curriculum is the one meant by the designer/developer So, the challenge for courseware developers is to design and develop the formal curriculum such that the best conditions are present for a correct interpretation by the teachers and therefore for an optimal computer integration at the operational level.

3. SOME RESEARCH OUTCOMES

The quantitative problem

Evaluating the outcome of the surveys referred to before and of many case studies (see for example, Johnson, 1985; Plomp & Van den Akker, 1988) the conclusion can be drawn that a large majority of schools in all educational sectors do have at present one or more computers and that in each of these schools there are at least a few trained teachers who are enthousiastically applying computers in their teaching. However, the large majority of teachers is still non-user and is also not trained in any computer use. A real integration of computers in the school's curricula demands the stake and commitment of a vast majority of the teachers. Therefore, in striving to enlarge the integration of computers in the school

curricula, one of the major problems is how to involve this large group of non-using teachers. A special feature of this problem stems from the situation that almost all schools are "computer using" and are aspire to have a "computer-friendly" climate, while many of their teachers have not even yet decided upon computer adoption.

We have to realize that for the integration of computers in education not only this quantitative problem has to be solved. In the remainder of this section we will see that there are also qualitative problems, which may be more wide-ranging and more difficult to solve and of which we hypothesize that their solution is a condition for the solution of the quantitative problem.

The qualitative problem

As the integration of the computer in the curriculum can be considered an educational innovation, we will discuss the qualitative problems in the context of the research on the implementation of educational innovations (Fullan, 1982, 1985), drawing heavily on the literature review of Keursten (1988a). A remark related to terminology has to be made: a real integration of the computer in either the formal or the operational curriculum means a successful implementation, and the reverse. We will therefore use integration and implementation interchangeably in this section.

Van den Akker (1987) developed a useful framework for the factors influencing educational implementation by distinguishing the following categories:

- **national (or state) context**: factors like national policy; expressed goals and values; place in the curriculum; available time (e.g. in school time tables), budget and materials; experiences with other national innovations; information about examination results, etc.
- **characteristics of the innovation**: factors like origin of the innovation (who asked for it, who developed the materials); its intentions (intentions of the developers, rationale and goals, most important characteristics of the intended teaching and learning approach); the codification (in materials and documents, which parts are already available, which demands make the use of computers to schools, teachers, students and others); available data about the implementation of the innovation and its influence on variables such as learner performance.
- **characteristics of the school**: we can distinguish between general factors and factors specifically related to the innovation. General factors include size, history (especially with respect to innovations), physical facilities, organizational structure, social context, school climate; and degree of support of school management and other relevant persons. More specific factors include the place of the innovation in the school curriculum, time and other means which the school is willing to invest, materials, joint agreements about the

innovation (such as content, instructional strategies, grouping patterns), and earlier experiences with the particular innovation in the school.

- **external support**: who supports; amount and frequency; orientation (directed at the individual or a group); format of support (such as information transfer, training, documentation or coaching); relations to other schools; voluntary or compulsary support; external or own initiative; finances.

When talking about the integration of the computers in the curriculum all these categories of factors may influence to a certain degree its success. They are listed here to illustrate the complexity of the problem we are discussing in this paper. However, within the scope of this paper we will restrict ourselves to the second category: **characteristics of the innovation.**

Computer implementation in the formal curriculum

Evaluating computer implementation in the formal curriculum includes evaluating the quality of educational software from a curricular perspective. Quality of educational software is unanimously mentioned as an important factor, while also (almost) unanimous dissatisfaction prevails about this quality. However, only in a limited number of references is the criticism explained or underpinned. Some of these explanations will be summarized:

- Much educational software is **isolated curricular material**, badly attuned to the curriculum (content, materials, strategies) which is in use in schools and therefore irrelevant to the school curriculum (Inspectie, 1987; Ridgway et al., 1984; Cox, 1987;). Hawkins and Sheingold (1986), for example, after studying the use of three pieces of innovative software in classrooms, conclude that "the curriculum in these classrooms had to be stretched or modified in some way to accomodate the technological functions of the innovative software. In these cases, adoption of the technology by the classrooms was not a process of simply incorporating new into old, but of reshaping what was there" (p.47). But a warning against the reverse is appropriate: if the software relates closely to the existing curriculum it is indeed easier for the teachers to use, but it is then often seen as just an "extra" (Cox, 1987, p. 43).
- Much software is **developed for individual use**, not taking into account the daily classroom practice and the practical constraints of a classroom with limited numbers of computers (CERI, 1986). This restriction makes a considerable impact on the planning and management talents of teachers.
- Much software is **poorly documented**, causing many unexpected problems for teachers (Jorde, 1985).
- Much of the early generation of software can be characterized by the "**the Quiz Syndrom**" (Mackey, 1987, p. 605). An innovation which appears to bring just one long question-

it observes that the software in Dutch elementary schools is almost without variation the drill and practice type.

- There is **no continuing stream of educational software** available for school subject matter domains (Kooreman & Moonen, 1987); most software is just "piecemeal" (Williams & Williams, 1984).

Computer Implementation In the operational curriculum

Problems in the operational curriculum, in the actual teaching-learning activities, can often be expressed as problems relating to teachers.

- An often-mentioned problem is the limited **selection of software** (CERI, 1986; Ridgway et al.,1984), especially because software is often poorly documented (Jorde, 1985). Moreover, many teachers lack the knowledge to effectively evaluate the quality of software (Knupfer, 1986), especially as there are only limited possibilities to test potentially useful software in short units of instruction (Balla, Gow & Burton, 1986).
- Teachers are often **ignorant** about computers and software (CERI, 1986; Johnson, 1985; Ridgway et al., 1986). This lack of knowledge and experience leads often to uncertainty, especially when the level of computer familiarization of the teacher is the same as or even lower than that of the students (Carmichael, Burnett, Higginson, Moore & Pollard, 1985). A consequence of this phenomenon may be that educational computing will be restricted to the limited level of expertise of the teacher (CERI, 1986).
- Teachers are often experiencing **unanticipated problems with their roles** (Carmichael et al., 1985; Johnson, 1985; Jorde, 1985). Computers are challenging teachers' existing instructional routines by opening up: other patterns of interactions with students, and to no longer utilize only expository teaching, but because more of a partner and guide of students. Many teachers are uncomfortable with these reprioritations and therefore try to minimize changes of this type (Cox, 1987; Plomp, Steerneman & Pelgrum , 1988). Real integration of computers in the curriculum demands a revision of their fundamental beliefs about teaching, learning and their roles as teachers, the necessity of which is often not seen beforehand (see for example, Elder, Courlay, Johnstone & Wills, 1987). All these aspects (the use of computers, other instructional strategies and the reconsidering of their roles) makes the introduction of the computer a multi-dimensional, and therefore complex innovation (Fullan, 1982).
- Teachers experience many **practical problems** when they start to use computers (Carmichael et al., 1985; Elder et al., 1987; Inspectie, 1987), which is for some teachers a reason to stop (Johnson, 1985). Computer use demands from teachers much management and organization effort which they do not always anticipate.

In summary, computer usage asks much personal investment (time, energy) from teachers which is often underestimated beforehand. This frequently leads to frustration, to suboptimal use of computers or even to stopping or not starting, because the "normal" activities have to go on. An effect which is reinforcing this is **unclarity about the possibilities** of computers in education **and about advantages** of their use (Knupfer, 1986; Mackey, 1987). There has been too much attention for the 'why' of computer use in education, and too little for 'how' to use them. Teachers lack clear pedagogical concepts for the new technologies in relation to the curriculum (CERI, 1986). Because of factors such as these, many teachers are not seeing the usefulness of changing their instructional routines and of starting to use computers in their curriculum, perspectives which clearly impede the implementation of computer use.

Relation to curriculum implementation

We will compare the results of computer implementation with the literature on curriculum implementation and see what we can learn from this comparison. We will do this from two perspectives, a teacher perspective (Doyle & Ponder, 1977), and a perspective relative to innovation in education (Fullan, 1982,1985; and Fullan, Miles and Anderson, 1986) .

The teacher perspective

Doyle and Ponder (1977) use the term "practicality ethic" to indicate that in common practice teachers will judge the practical merits of a proposal very soon after exposure to it. Teachers appear to use three general criteria to determine whether new proposals are "practical" for them: instrumentality, congruence and cost.

Instrumentality means "that a change proposal must describe a procedure in terms which depict classroom contingencies. Without this degree of understanding communicated by procedural specifications, teacher judgment concerning the practicality of a change proposal is nearly impossible" (p. 7). Teachers need concrete teaching experiences to attain a good understanding of the meaning of proposed change.

We conclude that this criterion is often not met: we saw that teachers usually do not get adequate opportunity to test software within the context of units of instruction (Balla et al., 1986), that software is often poorly documented (Jorde, 1985), and the wish of teachers for a pedagogical concept for computer use (CERI, 1986) seems to refer to a need for procedural specifications.

Congruence refers to "the extent to which a proposed procedure is congruent with perceptions of the teachers of their own situations" (Doyle & Ponder, p. 7, 8). Computer use appears to be a challenge to the existing instructional routine of the teacher, as we ave seen before. The criterion of congruence can also have a conserving effect, because the tendency

may develop to adjust so much to existing practice that real change becomes hardly possible Here lies a real challenge for the implementers of computer integration!

Cost is conceptualized by Doyle and Ponder (p. 8) as a ratio between amount of return and amount of investment; it refers primarily to the ease with which a procedure can be implemented and the potential return for adopting an innovation. We have seen that starting to use computers in the curriculum is asking from the teacher high investments in time and energy, while at the same time there is unclarity about the possibilities and advantages of computer use.

A dilemma shows up when we would like to take into account Doyle and Ponder's criteria. We already pointed to the conserving effect of congruence. A close attuning of the computer to the existing operational curriculum of the teachers may lead to a tendency among teachers to use the computer "earlier" and more intensively, but it may lead at the same time to non-innovative use or even to less meaningful uses.

In summary we may conclude that evaluation by teachers about the practicality of computer use is in many cases negative. This may be one of the causes of the gap which exists between the enthousiastic forerunners in a school, who do not worry about the extra investment in time and energy to accomplish some degree of computer integration in their teaching, and the nonusers who are often sceptical with respect to the great attention being paid to computers (Carmichael et al., 1985; Fullan et al.. 1986; Inspectie, 1987).

The Innovation perspective

Fullan et al. (1986) present a framework with ten factors influencing implementation, which is based on accumulated research on innovation implementation in education. Because we are restricting ourselves here to the formal and operational curriculum, we will also restrict ourselves to the factors related to the characteristics of innovation in an educational setting, namely clarity and complexity, consensus/conflict about the change, and quality and practicality of the change.

Clarity refers to the the degree of clear understanding of the practical meaning of a change proposal. As we have concluded earlier, the possibilities and advantages of computers for education are far from clear for many teachers and other people involved. Concrete practical experiences based on a high degree of a priori procedural specification will therefore be justified and useful (Fullan et al., 1986, p. 23). Fullan et al. point out as one of the dangers that teachers may develop a "false clarity", if they only incorporate the easy-to-learn features of computer use into their practice. There is evidence for this; Elder et al. (1987) found that teachers are not easily influenced to change their roles or to try to adjust computer use within their existing routines.

Complexity of an innovation arises from the number of components of instructional practice affected; the degree of difference from existing practices, materials and beliefs; and the difficulty of learning to make the necessary changes (Fullan et al., 1986, p. 23). As introducing computers in one's curriculum is not using new materials, but also means a change of instructional strategies and often also a reconsidering of educational beliefs, it is clear that we are facing here a complex innovation for the teacher and the school. This complexity is often increased by the poor quality of much educational software and the lack of user-friendliness of many hardware and software. It is therefore not surprising that real computer integration in the curriculum hardly exists (Inspectie, 1987).

Consensus and conflict refer to the need for and the appropriateness of the change and the priority of the efforts to implement the innovation relative to other concerns (Fullan et al., 1986). In our case, the prospects of integrating the computer in the curriculum will be greater when this meets a need of teachers, when it is appropriate for their own situation (in the sense of Doyle and Ponder's congruence) and when they are willing to give priority to the efforts needed. The acceptance and commitment of teachers can also develop during implementation when other conditions are favourable (such as effectivity of innovations, administrative commitment, adequate assistance) (Fullan et al.,1986, p. 39). This supports the view of Doyle and Ponder (1977) that teachers only can reach a good judgment of an innovation on the basis of concrete practical experiences. We saw earlier that Carmichael et al. (1985) concluded that in contrast to the enthousiasm of computer-using teachers, there is reservedness among nonusers. Fullan et al. (1986) suggest that a combination of consensus among administrators, parents and colleagues; positive first-user experiences and adequate support may reduce this reservedness.

Another point of importance is that in the beginning consensus can only be superficial because of lack of experiences with concrete, innovative applications of high quality. This implies that in case of computer use, real consensus only can be reached over time on the basis of a series of experiences of increasing educational sophistication and complexity.

Quality and practicality of innovation products refers to the fact that many innovations fail in practice because of poor-quality materials. Fullan et al. (1986) state that the chances for successful change are greater when the technical certainty of the innovations is already known, and when at least some of the benefits for students are immediately apparent to teachers. Achieving good and relatively immediate student results is one of the keys to developing commitment to change on the part of initially sceptical teachers (p.49). Innovation quality is also a matter of how "practical" the innovation seems to the teachers, who are attempting to change. An innovation is practical when it addresses salient student/teacher needs, fits well with the teacher's situation , and includes concrete how-to-do information. Practical does not mean easy, but it means the presence of concrete next steps toward

greater and more sophisticated implementation (p. 50). Fullan et al. (1986) also warn against the danger of sacrifying quality to reduce practical problems, because in doing this the possible yield of the innovation may also reduce. From our discussion of the literature on computer usage it appears that quality as well as practicality of educational software are often poor. Good-quality products with concrete procedural specifications may reduce these problems.

In summary we can conclude that the characteristics of an innovation, emerging from the literature on curriculum implementation, show great similarity with what we know from the research on the implementation of computer applications in education discussed before (Carmichael et al., 1985; Cos, 1987; Elder et al., 1987). So, when studying the problem of computer use from the perspective of the curriculum, it will be fruitful to apply research outcomes on curriculum implementation.

4. INTERMEZZO: SUMMARY OF THE PROBLEM

In this paper the integration of educational computer use is being discussed from a curricular perspective. We have elaborated the concept of curriculum (Fig.1), indicating that we are restricting ourselves to the integration of the computer in the formal curriculum (the codification of the curriculum in materials) and in the operational curriculum (the actual teaching-learning processes). In Section 3 we have summarized what we can learn from the literature on computer implementation and on curriculum implementa[illegible]d concluded that studying the problem of integration of the computer in the curriculum is in fact studying a curriculum implementation problem. So, integration and implementation can be used interchangeably in this context.

We already pointed to the dilemma of reducing implementation problems by attuning computer usage to the present situation and immediate needs of the teachers, and at the same time to the need to guarantee the quality and results of the innovation. A way to reduce the problems of the teachers, while doing minimal concessions to the desired quality of the innovation, is to develop educational software of high quality in the context of curriculum development, reflecting the best of computer use in a certain context and containing concrete procedural specifications for the teacher. This approach constitutes a real challenge for curriculum and educational software developers.

In the remainder of this chapter we will address two aspects of this challenge: (i) how to determine for what purpose the computer can be used the best in a curriculum (Section 5), and (ii) how to develop procedural specifications for educational software to offer teachers concrete how-to-do indications for effective use of software (Section 6).

5. STRATEGY FOR DETERMINING COMPUTER USE IN THE CURRICULUM

The central question in this section is how to determine whether the computer is an adequate instructional medium and certain computer use an adequate instructional method given a particular curricular situation (see Fig.1).

We will adopt a systems approach by taking as starting point that the computer should be used as a means to an end. The end should be, that students by participating in the the teaching-learning process (the operational curriculum), learn the predetermined knowledge and skills. An approach for the selection of methods and media is elaborated by Romiszowski (1981, 1984, 1986). As an additional illustration we will present in this chapter another approach, this one developed by the Center for Educational Research and Development (CERD) of the University of Twente (Mettes, Pilot & Roossink, 1981; Plomp, 1986; Smuling & Pilot, 1980). **Central idea** of this approach is that we need to have a clear picture of a desired instructional process before we can decide upon the choice of methods and media. In the approach of the CERD a model of the instructional process will derived from a model of the learning process of the student. We will first summarize the model of the learning process, followed by the model of the instructional process. Together they form a framework for discussing possible computer use in the curriculum.

A model of the learning process

The model we are discussing here is developed (based on Russian learning theories) to be applied in courses with a fixed content (in this case engineering courses in thermodynamics, electrotechnic, physics, etc.).

In the model a distinction is made between the result of learning and the way by which students attain this result. This way is a set of mental actions called a programme of actions and methods (PAM). A central idea in this model of the learning process is that learning can be conceived as a process of information processing. Presented information has to be observed, understood, processed and stored in such a way in the memory that the student is able to use it at the moment that he needs it. The model is summarized in Fig.2 (derived from Smuling & Pilot, 1980).

-- Insert Figure 2 about here --

In the first stage the learning activity involves orientating oneself to the intended learning result. Necessary for this is an explanation of essential knowledge elements and of subject-related mental actions. This orienting basis must contain all information necessary for a perfect performance of the necessary mental actions, such as the goal of the (mental) actions and the conditions under which the actions can and cannot be performed (including learning aids). The best orienting basis is both complete and presented to the student in a generalized form, so that a whole class of problems is covered.

The second stage is that students have to learn to carry out the set of mental actions (the PAM); exercising is needed. In case the students have to learn something totally new, the consecutive steps in the PAM have to be practiced extensively, first separately and then consecutively. It is also important that in this stage feedback occurs, so that it can be controlled if the development of the PAM is taking place in the right way. If this is not the case, measures must be taken.

The third stage of the model involves gaining an insight in the attained learning result, by evaluating whether this result is meeting a predetermined norm.

The fourth stage is the continuation of the learning process, either by returning to earlier stages to correct shortcomings, or by continuing to the next part.

Often a topic is divided up in several learning tasks, which implies that the cycle has to be worked through several times (the first time only on introductory level, the second time on a more advanced level, etc.).

The model in Fig. 2 is a model for a learning process, that is for learning activities to be performed by the student. These learning activities have to be supported by certain teaching or instructional activities.

A model of the instructional process

At each stage of the learning process at appropriate moments certain instructional activities have to take place. For example, if the learner needs feedback at a certain moment, then this should be given at that time and not some weeks later, because then possible misconceptions will be corrected too late.

In this context we are using the term **instructional function**, in the meaning of the set of activities which has to take place to make learning possible (see Fig.3, derived from Smuling & Pilot, 1980)

-- Insert Figure 3 about here --

The first instructional function is to offer an orientation: knowledge elements have to be presented, how to apply this knowledge has to be explained, also how to make the knowledge operational.

The second function is to arrange for student practice, with the possibility of receiving feedback during practicing.

The third function is testing --if necessary also during the previous learning process-- to check whether the student has reached the intended norm. If the student meets this norm, he may then continue to the next task; if not, then he receives feedback (Instructional Function 4) and must study the task anew.

There are in the model further some conditional functions, which are independent of the character and the content of the learning task (see Fig. 3).

Morphological chart

Within each instructional function the teacher can choose instructional methods and media. Often different combinations are appropriate.

The choice of media is complex and in part subjective. Clark (1985) has shown that the effectivity of instruction is not determined by the particular media (and the methods) which are used, but by the instructional concept within which the media are being used. Further the choice of the overall instructional strategy (as the translation of a philosophical or theoritical position regarding instruction into a statement of the way in which instruction should be carried out in specific types of circumstances) are determining the selection of instructional methods and media (Romiszowski, 1981). Romiszowski distinguishes two main categories of learning: reception learning and discovery learning, and in connection with those, two basic instructional strategies: the expositive strategy and the discovery strategy (with of course many variations on these two). For each basic strategy it is possible to draw up a list of appropriate instructional methods (see Romiszowski, 1982; p. 308) by which media (as the carrier of the messages) can be selected. Factors which play a role in the selection of methods and media are effective communication, reasonable costs, practical constraints, and human factors (such as preferred learning or teaching style). As an example, in a course on a certain subject area, the instructional function of "orientation" can be realized by giving explanation via a lecture, or self-studying of texts, or letting students watch audio-visual material, or by certain computer use, or a combination of these. So depending on the topic, the content, and objectives, the overall instructional strategy and grouping patterns, and taking into account the above mentioned factors, the curriculum developer and the teacher can explore the possibilities of shaping their curriculum. We can represent all these

possibilities in a so-called morphological chart (see Fig 4 for an example, derived from Mettes & Pilot, 1980, of an university-level engineering course with a fixed content).

-- Insert Figure 4 about here --

When curriculum (and courseware) developers and teachers are planning their curricula in this way, then the final choice of instructional methods and media is the choice of a "path" selected from the suitable possibilities (in Fig.4, for example Path A or B).

If one would like to have an appropriate role for the computer in either the formal or the operational curriculum, a strategy as discussed here can be followed. The question for which instructional functions the computer is an appropriate instrument, comes then to the question after the possible place of the computer in morphological charts like the one in Fig.4. By stating this question in the context of desirable learning activities and possible instructional functions, it is clear that there is no unambiguous answer to this question because it will depend on the specific teaching-learning situation and many other factors. However it is important to conclude that many possibilities for meaningful applications of the computer can be determined of one follows the type of approach presented here.

Some examples of the selection of forms of computer use as an instructional method taking into account the curricular context (although not following explicitly a strategy as presented here) can be found in Collis (1988b) and Educational Technology Center (1988).

6. DESIGNING FROM THE PERSPECTIVE OF THE USER

If in the context of a curriculum it is decided to use the computer to realize certain instructional functions, then the next question for the developer is how to design educational software such that a teacher will be able to use it in his operational curriculum in the way meant by the developer (supposing that he is doing a "good" job). This question is especially relevant when teachers are new or nonexperienced users of the computer. We concluded in Section 4 that real integration of the computer in the curriculum is a very complex change for (most) teachers as it demands also a change in their instuctional routines. It was also concluded that prodecural specifications, concrete directions for using the curricular materials (including educational software), may facilitate this process.

It is important to realize that this problem also has a student aspect, as incessant procedural questions asked by the student user may become a nuisance to both students and teachers (Mudd & Wilson, 1986). Also d'Arcy and Gardner (1986) pointed to the need for

comprehensive documentation support, such as with introductory and advanced user guides, classroom support materials, helpful audio tapes, and where possible a video, to illustrate classroom usage. Educational Technology Center (1988) in a research study on how teachers are affected by the challenges and ooportunities of computer technology also gives some relevant conclusions in this respect. They conclude that teachers need lesson plans, teaching aids, problem sets, and worksheets in order to carry out lessons with computer technology (p. 35). They also point out that, depending on prior experience with computers, the concerns of teachers are changing in emphasis, and that this dictates a corresponding evolution in the kinds of resources and supports that teachers seek. In keeping with this pattern, teachers with very little experience of computers often want a gentle introduction , paced to prevent the feeling of becoming overwhelmed by the machinery (p. 40). Fullan et al. (1986) are referring to the same type of demands in their design requirements for a comprehensive implementation support strategy.

The next question is how to design good support materials.
Van den Akker (1988) investigated the effect of such materials on teachers who are first users of a new science education approach. His conclusion is that procedural specifications can indeed be an effective means in bringing about change and also offer the teacher important help in organizing his instruction. They can also stimulate the teacher to reflect on his own instructional routines and on the possibilities of the innovation within them. The meaning of these conclusions for computer implementation becomes especially evident from an examination of the similarities between the key problems of teachers confronted with a new approach in science education and the problems with computer integration we discussed earlier. This is obvious from Van den Akker's **list of key problems** teachers have with innovative science education, on which he based the procedural specifications in his support material:

- changes in the didactical role of the teacher only with great difficulty;
- a lack of background knowledge and self-confidence with respect to required knowledge and skills;
- complex and time-consuming lesson preparation;
- insufficient view of possible learning effects.

The specifications of van den Akker are divided into four categories (in comformity with the four key problems of the teachers):

1. **Lesson preparation**, to offer the teacher support as concrete as possible on the material-organizational aspects of lesson preparation, as well as an orientation and anticipation on the course of the lesson;

2. **Content**, to provide the teacher with an adequate knowledge basis, which can help him feel secure in his working with students;
3. **Didactical role**, to provide the teacher with directions as concrete as possible about the "what", "when" and especially the "how" of his didactical activities during the lesson;
4. **Learner effects**, to provide the teacher with reference points in the learning processes and outcomes for attuning his actions during the lesson.

Van den Akker elaborated each category with concrete hints for the curriculum developer for developing procedural specifications.

Because of the similarity in problems in computer implementation it is worthwhile to investigate whether curriculum materials with computer use (courseware) can be based on the same high degree of procedural specifications. Keursten (1988b) applied these specifications in a small-scale project by developing courseware for a series of eight lessons (on the theme of weather, for the final grade of primary school) to be used by teachers who had no experience with computers. The courseware package he developed consisted of written lesson materials for the teachers containing the subject matter and directions for lesson preparation and execution; educational software with a manual about its operation; and learner material.

The procedural specifications for the package were divided among the written lessons and the manual of the software. In the written lessons the following categories were incorporated:

- general characterization of the curriculum in terms of objectives, content, time (also division of time over different lessons), expected learning effects.

Per lesson:

- a summary to provide the structure;
- hints for lesson preparation, including issues like learning aids, classroom organization, organization of the lesson in keywords, personal preparation by teacher;
- hints for lesson execution, suc as an overview of activities, hints for the instruction, organization and learner support;
- background information about the topic so that in principle it is not necessary for a teacher to use other sources during the lesson preparation.

The manual of the computer program consisted of:

- directions for the use of the computer (especially important as the teachers had no experience with computers);
- description of the objectives (short, because it is also part of the written lesson materials);
- directions for the use of the software (most important part, as it must answer all possible questions teachers may have in using the program);

- questions about classroom organization, which the teacher has to answer himself, but will help him to organize his classroom optimally.

Evaluation of the use of this package with five teachers had promising results. They were able to use the software as meant by the designer. Almost all specifications were judged positively, which implies that the teachers found in the package useful information for lesson preparation and execution. Most positive were the judgements concerning the specifications about the use of the computer and the computer program; also high were those on the directions for lesson preparation and for lesson execution and the background information about the subject matter. Teachers judged as less useful the part on classroom organization and the justification of the package as a whole.

In conclusion, in this limited experiment, the procedural specifications of the courseware package as whole (written lesson materials and software) appeared to work and to be an appropriate means to reduce anticipated implementation problems. It is worthwhile to investigate this approach further.

7. CONCLUDING REMARKS

Given the frequent criticism of the quality of educational software, and the problems of teachers with integrating computer use in their teaching-learning activities, this paper contains a plea to develop educational software in the context of curriculum development, or at least by taking into account the context of the (formal and operational) curriculum. We have suggested some strategies which may be applied in such an approach and from which we may expect that the chance of the type of problems we discussed in Section 4 will be reduced.

However, we have to realize that we are emphasizing in this chapter the curriculum part of the problem (one may also say the "product" part) by conentrating on the desired characteristics and quality of courseware. We must not forget that there are also other factors which determine the success of introducing computers in the curriculum, such as the national (or state) policy, which may provide important stimuli; the characteristics of the school (administrative support, interaction basis among teachers, facilities for inservice training); and the degree of external support (see Section 4).

We already pointed to the dilemma created by striving to attune educational software to existing educational practice (Sections 3 and 4). We have not yet pointed to an important consequence of the development of information technology in our society for education in general and its consequences for the curriculum: the increasing emphasis on problem

solving, on dealing with information and on experimenting As a consequence, new approaches of existing subject matter domains may be necessary. Information technology evokes these changes, but is also a means to make these changes possible. When we do not take into account this aspect -- by challenging existing curricula -- then there will be a real danger that computer use in education will remain restricted to "trivial" applications.

REFERENCES

Akker, J.J.H. van den (1987). *The design of the impact study.* Enschede: Universiteit Twente.

Akker, J.J.H. van den (1988). *Ontwerp en implementatie van natuuronderwijs* (Design and implementation of science education). Lisse: Swets & Zeitlinger.

Alessi, S.M., & Trollip, S.R. (1985). *Computer-based instruction.* Englewood Cliffs (N.J.): Prentice-Hall.

Balla, J., Gow, L., & Burton, P. (1986). Computers in the teaching process and software development: Cooperation the key. *Education & Computing, 2,* 265-271.

Becker, H.J. (1986). *Instructional uses of school computers: Reports from the 1985 national survey* (issue nr. 1). Baltimore: Center for Social Organizations of Schools, John Hopkins University.

Carmichael, H.W., Burnett, J.D., Higginson, W.C., Moore, B.G., & Pollard, P.J. (1985). *Computers, children and classrooms: A multisite evaluation of the creative use of micro-computers by elementary school children.* Ontario: Ministry of Education.

Centre for Educational Research and Innovation (1986). *New information technologies: a challenge for education.* Paris: OECD.

Clark, R.E. (1985). Evidence for confounding in computer-based instructino studies: Analyzing the meta-analyses. *ECTJ, 33*(4), 249-262.

Collis, B. (1988a, July). *Manipulating critical variables: A framework for improving the impact of computers in the school environment.* Paper presented at the EURIT '88 conference, Lausanne, Switzerland.

Collis, B. (1988b). *Computers, curriculum, and whole-class instruction: Issues and ideas.* Belmont, CA: Wadsworth Publishing Company.

Collis, B., Kass, H., Kieren, T. E., & Wood, P. (1988, June). *Gender differences in Canadian grade 11 students' interactions with computers: Results of a national survey.* Paper presented at the annual meeting of the Canadian Society for Studies in Education, Windsor, Ontario.

Cox, M.J. (1987). Computer-assisted learning/CAL and the future. In Tj. Plomp, K. van Deursen, & J. Moonen (Eds.), *CAL for Europe* (pp. 33-49). Amsterdam: North Holland.

D'Arcy, J., & Gardner, J. (1986, May) *Learning from teachers. Teachers' perspectives of relevant courseware and training provision.* Paper presented at the EURIT '86 conference, Enschede, The Netherlands

Doyle, W. & Ponder, G.A. (1977-1978). The practicality ethic in teacher decision making. *Interchange, 8* (3), 1-12.

Elder, R.J., Courlay, J., Johnstone, M. & Wills, R. (1987). Microcomputers in primary education. In: N. Rushby (Ed.), *Computer based learning, selected readings* (pp. 120-126). Oxford: Pergamon Press.

Fullan, M.G. (1982). *The meaning of educational change.* New York: Teachers College Press.

Fullan, M.G., (1985). Curriculum implementation. In T. Husen & T. N. Postlethwaite (Eds.), *The international encyslopedia of education* (pp. 1208-1215). Oxford: Pergamon Press.

Fullan, M.G., Miles, M.B., & Anderson, S.A. (1986). *A conceptual plan for implementing the new information technology in Ontario schools.* Ontario: Ministry of Education.

Gerlach, V.S. & Ely, D.P. (1980). *Teaching and media. A systematic approach.* Englewood Cliffs: Prentice Hall Inc.

Goodlad, J.I., Klein, M.F., & Tye, K.A. (1979). The domains of curriculum and their study. In J.I. Goodlad et al., *Curriculum inquiry: The study of curriculum practice* (pp. 43-76). New York: McGraw-Hill.

Hawkins,J., and Sheingold, K. (1986). The beginning of a story: Computers and the organization of learning in classrooms. In J.A. Culbertson & L.L. Cunningham (Eds.), *Microcomputers in education* (85th NSSE Yearbook) (pp. 40-58). Chicago: The University of Chicago Press.

Inspectie Ministerie van Onderwijs en Wetenschappen, (1986). *Onderwijs en informatietechnologie: Stand van zaken in het schooljaar 1985/1986* (Inspectorate report No.7) (Education and information technology: State of affairs in the school year 1985/1986). The Hague: Staatsuitgeverij.

Johnson, J., (1985). Microtrends in the middle school: Beyond computer literacy training. *Educational Technology, XXV.*

Jorde, P. (1985). Microcmputers: Tempering the pro-innovation bias. *Education, 106*, 388-393.

Keursten, P. (1988a). *Integratie en implementatie van computergebruik in het natuuronderwijs-curriculum* (Integration and implementation of computer applications in the (science) curriculum). Enschede: University of Twente, Dept. of Education, Div. of Curriculum Technology & Educational Adminstration.

Keursten, P. (1988b). *Computertoepassing in het natuuronderwijs-curriculum* (Computer applications in the science education curriculum). Enschede: University of Twente, Dept. of Education, Div. of Curriculum Technology & Educational Adminstration.

Knupfer, N.N (1986a). *Change, implementation and equity: A model design for a computer education plan* Madison: University of Wisconsin.

Knupfer, N.N. (1986b). *Implementation of microcomputers into the current K-12 curriculum: A critical discussion of issues.* Madison: University of Wisconsin.

Kooreman, H.J. & Moonen, J.C.M.M. (1987). *Beleidsonderzoek proefstations. Inventarisatie van praktijkervaringen en aanknopingspunten voor verder beleid.* Enschede: COI.

Leithwood, K.A. (1982). The dimension of curriculum innovation. *J. Curriculum Studies, 13* (1), 25-36.

Mackey, B. (1987). Effective educational courseware - the microcomputer as a learning medium. In J. Moonen & Tj. Plomp (Eds.), *EURIT '86: Developments in educational software and courseware* (603-610). Oxford: Pergamon Press.

Martinez, M., & Mead, N.A., (1988). *Computer competence: The first national assessment.* Princeton, NJ: Educational Testing Service.

Mettes, C.T.C.W., Pilot, A., & Roossink, H.J. (1981). Linking factual and procedural knowledge in solving science problems: A case study in a thermodynamics course. *Instructional Science, 10,* 333-361.

Mettes, C.T.C.W., & Pilot, A. (1980). *Over het leren oplossen van natuurwetenschappelijke problemen* (On the learning of solving science problems). Enschede: University of Twente, Center for Educational Research and Development.

Mudd, S., & Wilson, W. (1987). Achieving curriculum-integrating computing. *Computing Education, 8,* 173-177.

Plomp, Tj. (1986). De computer in het curriculum (The computer in the curriculum). *Nederlands Tijdschrift voor Opvoeding, Vorming en Onderwijs, 2* (3), 129-141.

Plomp, Tj., & Akker, J.J.H. van den (1987). Curriculum and implementation aspects of the introduction of information technology in education. In J. Moonen & Tj. Plomp (Eds.), *EURIT '86: Developments in educational software and courseware* (xxxi-xxxvi). Oxford: Pergamon Press.

Plomp,Tj., Steerneman, A.H.M., & Pelgrum, W.J. (1988). Curricular cahnges as a consequence of computer use. In F. Lovis & E.D. Tagg (Eds.), *Computers in education.* Amsterdam: Elsevier Science Publishers.

Romiszowski, A.J. (1981). *Designing instructional systems.* London: Kogan Page.

Romiszowski, A.J. (1984). *Producing instructional systems.* London: Kogan Page.

Romiszowski, A.J. (1986). *Developing auto-instructional materials.* London: Kogan Page.

Ridgway, J., Benzie, D., Burkhardt, H., Coupland, J., Field, G., Fraser, R., & Phillips, R. (1984). Conclusions from CAL tastrophies. *Computers in Education, 8,* 93-100.

Smuling, E B., & Pilot, A. (Eds) (1980). *Orientatie op leren en onderwijzen* (Orientation on learning and teaching). Enschede· University of Twente, Center for Educational Research and Development.

Steerneman, A.H.M. (1988). *Ervaringen met computergebruik in drie scholen* (Experience with computer use in three schools). Enschede: University of Twente, Dept. of Education.

Taba, H. (1962). *Curriculum development: Theory and practice.* New York: Harcourt, Brace & World.

Taylor, R. (Ed.). (1980). *The computer in the school: Tutor, tool, tutee.* New York: Teachers College Press.

Williams, F. & Williams, V. (1984). *Microcomputers in elementary education; Perspectives on implementation.* Belmont, CA: Wadsworth Publishing Company.

Figure 1:. Curriculum manifestations and components.

curricular components— / curriculum manifestations	objectives	content	instructional strategies	grouping patterns	curricular materials	student evaluation	time	space
ideal								
formal								
perceived								
operational								
experiential								

Figure 2: Model of the learning process

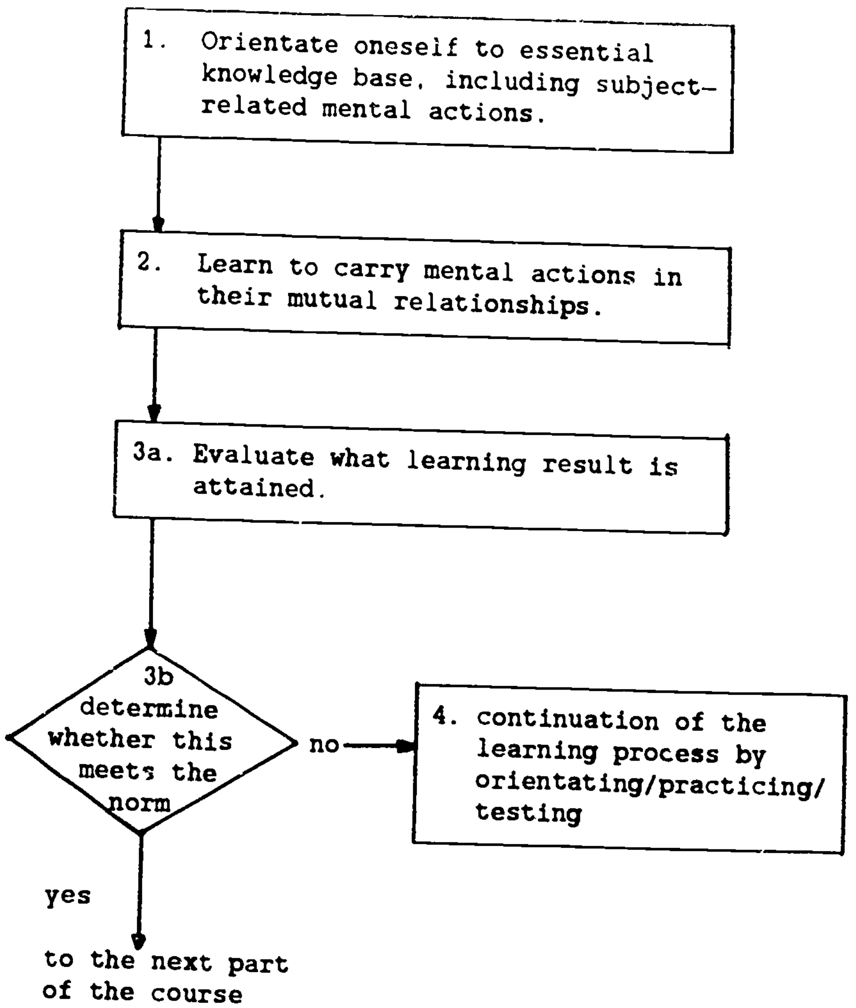

Figure 3: Overview of relationships between phases in the learning process and instructional functions (for fixed content learning).

PHASES IN LEARNING PROCESS (student)	INSTRCUCTIONAL FUNCTIONS (teacher)
	Conditional functions: a. motivate b. assume to entering level/sit c. give insight in goals and objectives
1. Orientate oneself to essential knowledge elements, and on the (subject related) mental actions	1. Orientation: a. Present knowledge elements b. Present subject related mental actions, including their mutual relationships c. Make these operational by presenting applications and overviews
2. Learn to carry out mental actions in their mutual relationships by practicing	2. Practicing: a. Offer opportunities for practicing (independent by or cooperatively) b. Provide feedback during practicing
3. Get insight in attained learning result	3. Testing of learning result: a. Assess attained results b. Determine whether this meets the norms
4. Continue learning process by orientating, practicing, testing	4. Feedback based on test results

Figure 4. Example of morphological chart with per instructional function some suitable instructional methods and media.

Instructional functions	Instructional methods and media 1	2	3	4
ORIENTATION 1. Presenting subject matter	lecture + self study + syllabus	lecture + working group	self study: book(s) syllabus	self study: books + video + tutorial (CAI)
2. Making operational — presenting applications				
2. Making operational — making overviews	part of lecture	part of working group	part of self study	
PRACTICING 3. Offer opportunities	working group individual	working group individual + assign-ments	some form of CAI	small group + self study
4. Provide feedback during practicing	teacher during working group	teacher + peer during working group, oral + written model solutions	outside working group written model solutions	some form of CAI + teachers and peer during working group
TESTING 5. During learning process (diagnostic)	written test during working group	special testing sessions	computer aided testing	
6. Testing at the end	written exam (open) questions	written multiple choice test	computer aided testing	written essay/ report
FEEDBACK 7. Activities directed at removal of shortcomings	special working group	extra lectures + model solutions	some form of CAI + consul-ting hours teacher	

A B